

which have since been received by the Paris Museum; so that this character is thus shown to be a constant one. It seems probable, however, that it will in the end be found unnecessary to retain *Scaptochirus* as a genus distinct from *Talpa*, since *T. leptura* has so exactly the same broad muzzle and stout powerful teeth, and the difference in the dental formula only consists of the absence of one of the two minute teeth following the canine-like first lower premolar.

The following are the four different dental formulæ found among the moles:—

Inc.  $\frac{3}{3}$ , C.  $\frac{1}{1}$ , P.M.  $\frac{4}{4}$ , M.  $\frac{3}{3}$ ,  $\times 2 = 44$ . (*T. europæa*, *cæca*,  
*mizura*\*, &c.)

Inc.  $\frac{3}{2}\dagger$ , C.  $\frac{1}{1}$ , P.M.  $\frac{4}{4}$ , M.  $\frac{3}{3}$ ,  $\times 2 = 42$ . (*T. wogura* and  
*insularis*.)

Inc.  $\frac{3}{3}$ , C.  $\frac{1}{1}$ , P.M.  $\frac{3}{4}$ , M.  $\frac{3}{3}$ ,  $\times 2 = 42$ . (*T. leucura* and  
*leptura*.)

Inc.  $\frac{3}{3}$ , C.  $\frac{1}{1}$ , P.M.  $\frac{3}{3}$ , M.  $\frac{3}{3}$ ,  $\times 2 = 40$ . (*S. moschatus*.)

# LI.—Remarks on a Pathogenic Schizophyte †.

By Prof. H. J. DETMERS.

WHEN about two and a half years ago it became my duty to investigate the prevailing Swine-plague, the so-called Hog-cholera, I first endeavoured to ascertain the nature and the cause of that disease, and to accomplish my object made numerous post-mortem examinations, and paid special attention to the microscopic examinations of the blood and of the morbid products and morbid tissues. Although the microscope at my disposal at the beginning of my investigation was only a small No. viii. Hartnack stand with three Hartnack and Prazmowski objectives (a 1-inch, a  $\frac{1}{4}$ -inch, and a  $\frac{1}{8}$ -inch imm. and correctives), and consequently not a strictly first-class instrument, and in its performance by no means equal to the work of a Tolles or a Zeiss, I soon became convinced that the blood, the morbid products, and the morbid tissues of

\* Günth. P.Z. S. 1880, p. 441.

† Prof. Owen (Odont. i. p. 416, footnote) says, "In the *T. moogura*, Temm. (lege *wogura*), the inferior canine is absent." From the examination of several specimens of the Japanese mole it appears to me to be rather the third incisor which is absent, there being no space whatever, when the jaw is closed, between the hinder edge of the third lower tooth and the anterior edge of the upper canine; and, moreover, it is not set in the same line as the first two teeth, as the third incisor is in the other moles, but is placed somewhat internal to them, just as the canine is in the common species.

† From 'Science,' May 7, 1881. Read before the State Microscopical Society of Illinois, April 8th, 1881.

the diseased and dead animal invariably contained, while fresh and not tainted by putrefaction, a certain kind of Schizophytes or *Bacteria*. The same presented themselves in three different shapes, namely as small globular *Bacteria* or *Micrococci*, as *Zoöglæa*-masses or clusters, imbedded in or kept together by a viscous mass, and as little rods or filaments. I soon found that all three forms belong to the same organism, and represent only different stages of development. The first or globular form predominated in the blood, the second in the morbid tissues (for instance, in the diseased portions of the lungs and in the lymphatic glands), and the rods occurred in greatest numbers in such morbidly changed parts and morbid products (for instance, in the ulcerous tumours of the intestines) as are accessible to atmospheric air and other external influences.

The constant occurrence of these Schizophytes soon made it appear probable that their presence is not merely accidental, but that very likely the same are connected with, and characteristic of, the morbid process of the disease. To get at the facts was one of my principal endeavours. How far I have succeeded I leave to others to judge.

Careful and repeated macroscopic and microscopic examinations of the tissues, but especially of the lungs (which, by the way, are always more or less affected by the morbid process of Swine-plague), soon revealed the fact that the principal morbid changes are brought about in the following way:—The finer capillary blood-vessels become obstructed or plugged, the more fluid portions of the blood exude into the tissues (in the lungs principally, and at first into the lobules, and then into the interlobular connective tissue); some, and, particularly in young animals, not seldom a great many, of the finest capillaries rupture, and innumerable small extravasations of blood, visible to the naked eye as tiny red spots, are deposited in the tissue. In the skin, subcutaneous tissue, and intestinal membranes the process is essentially the same; but to follow it further would lead too far for the present. Let me therefore mention another fact. While the blood taken from a vein of a diseased or dead pig invariably contains a large number of spherical *Bacteria* or *Micrococci*, and very few and usually small *Zoöglæa*-masses, the diseased parts of the lungs, and especially the stagnant blood which oozes out of the capillaries if the diseased parts of the lungs are cut into small pieces, invariably contain, besides *Micrococci*, numerous and large *Zoöglæa*-masses, which are most of them much larger than the blood-corpuscles, and abundantly large enough to clog the finer capillaries. All this of course does not prove that the Schizophytes constitute the cause of

the morbid process. I therefore resorted to experiments. Having found that any inoculation of a healthy pig with the fresh pulmonary exudations of a diseased or dead animal invariably produces the disease in from three to fifteen days, or, on an average, in six days, I concluded it might be ascertained in two different ways (in a negative and in a positive way) whether or not the Schizophytes constitute the cause of the morbid process. If it were possible to free the Schizophytes from every thing, and to transfer the same without any vehicle whatever from one animal to another, for instance, like a louse or an itch-mite, the question would be very soon answered. But as that cannot be done, I had to get at the facts in a more indirect way. I repeatedly charged two ounces of an innocent fluid, at first pure and fresh milk, then boiled milk, mutton-broth, afterwards water, and finally albumen, with one drop of the infectious pulmonary exudation containing an abundance of Schizophytes. In about three days the fluids thus charged (which, by the way, were kept at a suitable temperature) were found to be swarming with Schizophytes identical in appearance with those found in the pulmonary exudation; and every inoculation made with these fluids proved to be effective; but in most cases the attack produced was of a comparatively mild type. To go further into particulars would take too much time; I therefore have to refer for particulars to my reports to the Commissioners of Agriculture. One thing, however, I must state. The fluid transferred by each inoculation was less than half a drop; but this half drop contained innumerable Schizophytes, while, as far as could be ascertained by careful microscopic examinations, nothing else contained in the original exudation had multiplied. Consequently nobody, unless he believes in the power of Hahnemannian dilutions, will contradict me and say the effect of the inoculations is brought about, not by the Schizophytes, but by an unseen and unknown virus, or chemical something, the existence of which cannot be proved. I was, however, not satisfied with these positive results, and concluded to try also the negative way. Knowing that it is impossible to separate the Schizophytes from their vehicle, I tried to free the latter from the Schizophytes, and resorted to filtration. I filtrated the pulmonary exudations through half a dozen of the finest filtering-papers obtainable, but found my effort to be in vain; for the filtrate, although freed from the *Zoöglæa*-masses and rod-shaped *Bacteria*, yet contained numerous *Micrococcus* forms. The filtrate was put in a vial with a tight-fitting glass stopper; and when examined three days later it contained a great many rod-shaped *Bacteria* and comparatively few *Micrococci*. I therefore filtered it again, with

the same result, except that the *Micrococcus* forms were not so numerous after the second filtration as after the first. So I filtered the exudation three or four times, each time through from four to six filtering-papers, and at intervals of about three days, till I was finally not able to detect any *Micrococci* in the now limpid filtrate. Inoculations with this filtrate proved to be ineffective. At another time (in the following winter) I tried again to free pulmonary exudation from the Schizophytes by means of filtration, but did not succeed. The filtrate always after each filtration contained numerous *Micrococci*. Whether in this second attempt I did not hit the right time for my second and third filtrations (that is, a time at which most or all of the *Micrococci* had developed into rod-shaped Schizophytes or filaments), whether the temperature was too low (the first successful attempt was made in the summer) and therefore the development of the Schizophytes was irregular or retarded, whether my filtering-papers were not fine enough, or whether all these circumstances combined made the filtration a failure, I do not know. An inoculation made with this filtrate proved to be effective; but the disease produced was of a very mild character; at any rate the animal recovered.

If more proof is yet required that the Swine-plague Schizophytes and nothing else constitute the infectious principle of that disease (and it seems that the above facts, which have been published more fully in my reports to the Commissioner of Agriculture, are not deemed sufficient), the following facts, if not making it absolutely certain, will at any rate, especially if considered *in toto*, to a great extent corroborate the assertion that the Schizophytes have and must have a causal connexion with the morbid process.

1. It has been and can be everywhere observed, where Swine-plague is prevailing, that the infectious principle floating in the air is attracted and taken up by sores, wounds, and even scratches, but does not enter the animal organism through the whole skin and through perfectly healthy respiratory mucous membranes.

2. Antiseptics or medicines which are either directly poisonous to the lower forms of organic life or destructive to those conditions under which low forms of organic life thrive and develop, and, among those antiseptics, especially carbolic acid, iodine, hyposulphite of soda, benzoate of soda, thymol, &c., have proved to constitute almost sure prophylactics. As one of the conditions necessary to the development of Swine-plague *Bacteria*, it seems that a certain degree of animal heat has to be regarded. At any rate after and while the

animal heat of a pig is reduced, by a continued treatment with carbolic acid, from the normal ( $102^{\circ}$  to  $104^{\circ}$  F.) to an abnormally low temperature (say  $96^{\circ}$  to  $97^{\circ}$  F.), every inoculation with fresh infectious material has so far proved to remain ineffective. Further, the various antiseptics which have proved to be good prophylactics are very dissimilar in their chemical affinities and actions; and their prophylactic effect cannot very well be explained if the infectious principle is a chemical agency, a virus, or a poison, but is explained if the same consists in something endowed with life and power of propagation.

3. If the morbid process, the morbid changes effected, particularly the exudations and extravasations of blood on the lungs and in the skin, and the qualitatively unchanged condition of the blood (that is, excepting such changes in its composition as are evidently the product or necessary consequence of the morbid changes) are taken into consideration, it becomes obvious that something which causes obstructions in the capillary system (embolism) must constitute the cause; and nothing whatever able to accomplish that result can be found, except the colonies or clusters of Schizophytes, the *Zoöglæa*-masses imbedded in a viscous substance, while, on the other hand, these *Zoöglæa*-masses are never absent in a case of Swine-plague.

If I am allowed to digress a little, it may be here mentioned that I am well aware of the fact that German and French investigators claim for certain, and it may be for all, kinds of pathogenic Schizophytes chemical actions or fermenting properties; and undoubtedly many of them, especially among those belonging to the genus *Bacillus* (I mention *B. anthracis*) and probably some others, do possess and exercise such properties and cause fermentation. As to the Swine-plague Schizophytes, I have not been able to observe any fermenting effect or chemical action, except such as necessarily results from depriving the animal organism of certain elements and material, appropriated by the Schizophytes, and necessary to their subsistence and propagation. All other morbid changes appear to be the consequence of the obstruction of the capillary system by the *Zoöglæa*-masses, and therefore are the product of a mechanical and not of a chemical agency.

4. The adversaries of the so-called "germ theory" of disease, well knowing that a perfect separation of the Schizophytes (*Micrococci*, *Bacteria*, or *Bacilli*, as the case may be) from their vehicles, the animal tissues and fluids, is impossible, demand absolute proof. If conclusions may be drawn



from analogy between diseases of animals and plants, Prof. T. J. Burrill\*, of the Illinois Industrial University, more favoured by the nature of the objects of his investigation (apple-trees, pear-trees, and peach-trees), has furnished evidence, amounting to almost absolute proof, that the so-called blight of apple-trees and pear-trees and the so-called "yellows" of peaches are caused by Schizophytes similar in size (but otherwise not identical) to those which I consider as constituting the cause and infectious principle of Swine-plague, as will be seen by consulting the transactions of the meeting of the American Association for the Advancement of Science in Boston, 1880.

5. If the infectious principle were a chemical poison or virus, its action, one would suppose, would under all circumstances be exactly the same, and the malignancy of the morbid process and the time required for its development (the so-called period of incubation, or, more correctly, stage of colonization) would not be subject to changes dependent upon the season of the year, upon the individuality and temperature of the animal, and upon other yet unknown external influences, as is undoubtedly the case. An organic poison or virus, one would suppose, would act somewhat like the virus of a poisonous snake. In the same localities, in the same places, or the same yards and pens, and among the same breeds of hogs, in which the disease was exceedingly malignant in 1878, it was, as a rule, much milder in 1879, and still milder in 1880. As such are unmistakable facts, repeatedly and everywhere observed, it must be concluded that nothing but what is able to undergo changes, is subject to growth and development, and acquires vigour and propagates rapidly under favourable, but is weakened and multiplies slowly under unfavourable circumstances (in other words, nothing but what is corporeal and endowed with life), can constitute the cause.

6. If the cause and infectious principle of Swine-plague were a chemical poison or virus, one would suppose a cessation of the morbid process would be impossible, and an animal would never recover while its organism contains an abundance of the infectious principle in an effective condition—as is undoubtedly the case, because convalescents and animals nearly recovered frequently communicate the disease, even in a fatal form, to other healthy pigs; further, the fact that an animal once recovered possesses but little predisposition for future infection, or is seldom attacked a second time even if ever so much exposed, and then only contracts the disease in a comparatively mild form, could never be explained. But the whole

\* 'Science,' vol. i. pp. 162, 191.

presents an entirely different aspect, and admits explanation, if low and minute forms of organic life, such as the Schizophytes of Swine-plague, which, by developing and multiplying, finally destroy or exhaust in an animal organism the conditions necessary to future development and propagation, constitute the cause and the infectious principle (*cf.* an article entitled "The Destruction of Germs," in 'Popular Science Monthly,' communicated in extract in R. Hitchcock's 'Microscopical Journal,' Nov. 1880).

7. If some part or organ of a pig infected with Swine-plague happens to be in a state of congestion, such a part invariably attracts the infectious principle, and becomes a prominent, if not the principal, seat of the morbid process—a fact difficult of explanation, unless the infectious principle is something solid or corporeal.

8. The adversaries of the so-called "germ theory," as they are pleased to call it, demand absolute proof of those who claim that certain infectious diseases owe their origin or existence and spreading to very minute forms of organic life. They cannot deny that these forms exist, can be found, and have been shown; but they forget to show their virus, poison, fluidum, or chemical something. Does the latter exist only in their imagination? If the adversaries of the so-called "germ theory" demand absolute proof on our side of the question, let them set a good example and furnish it on their side, or only produce their virus, fluidum, or whatever it may be, and we will gracefully acknowledge that we are mistaken and have laboured in vain.

9. With the very best objectives ever made, and a fair ability to handle the microscope, I have never been able to find any thing identical with the Swine-plague Schizophytes in the blood and tissues of other healthy animals. When I commenced my investigation, the best objective at my disposal was a very fair 1-9 four-system immersion-lens of Hartnack and Prazmowski; but I soon found it be insufficient, and procured a 1-16 immersion of the same makers. This, too, after a while, did not give satisfaction, and I received a 1-12 (nominally 1-10) glycerine immersion of R. B. Tolles, which that renowned maker afterwards exchanged for a duplex 1-10 homogeneous immersion. This latter objective proved to be a very superior lens, and gave me glimpses of things of which I desired to see a little more—it showed flagella on *Bacillus subtilis*, which I had never seen with any of the other objectives; and so I thought, with a higher power, and a still more perfectly corrected lens, if a more perfect correction could be made, I might be able to see more plainly

the distinguishing forms and characteristics of the Swine-plague Schizophytes, and also learn a little more about their mode and manner of propagation. I therefore asked Mr. Tolles to make me a higher-power objective especially adapted to my work; and he has furnished me a duplex 1-15 homogeneous immersion objective (in reality a little more than a 1-16), which is, beyond comparison, the best objective I have ever seen. It is even superior, in definition and flatness of field, to a magnificent 1-18 homogeneous immersion objective (in reality a 1-20) of Carl Zeiss, made to order a month or two ago.

As to a proper generic place and name of these Swine-plague Schizophytes, I am at a loss. The best authorities (Cohn, Klebs, and others) who have attempted a classification are somewhat undecided themselves, and do not agree where generic lines ought to be drawn. At any rate the Swine-plague Schizophytes do not fit into any of the genera proposed. They are not *Bacteria*, because the single cells are spherical and not oblong; they can hardly be considered as *Micrococci*, because the same are bispherical in their advanced stage of development; and they cannot be classed among the *Bacilli* on account of their forming *Zoöglæa*-masses. I have therefore preferred to use, for the present, that name which, without any serious contradiction, is given by modern investigators to the whole family, Schizophytæ or Schizophytes, or the older name introduced by Nägeli, Schizomycetes.

The Swine-plague Schizophytes present themselves, according to their stage of development, in three different forms and shapes. Their simplest form, it seems, is that of a *Micrococcus*, or of a small globule of about 0.7 or 0.8 microm. ( $\frac{1}{33566}$  inch) in diameter. It occurs invariably in the blood, the morbid products, and exudations, &c. of the diseased animals, and is never absent, but can always be found, though in some cases in much greater numbers than in others. The second form is bispherical, the spherical cell having duplicated itself by a gradual contraction in the middle, while growing endwise. These bispherical Schizophytes are always more or less numerous, and are motile, or move about, provided the temperature of their vehicle (lung-exudation or blood-serum, for instance) is not too low. Some of them, but probably only those which are separated from a larger chain, as will presently be explained, are provided, at any rate at one end, with a flagellum (a postflagellum), which, however, is so exceedingly fine that it can be seen only with the very best high-power objectives, like a Tolles 1-15, and the most favourable light obtainable, and even then only while the Schizophyte is slowly



moving. I have never yet been able to see it while the Schizophyte was at rest.

These double *Micrococci*, or bispherical Schizophytes, soon undergo further development. Each single cell soon again contracts in the middle while growing endwise, and at the same time separates more and more, and becomes partially independent of its sister cell, with which, however, it remains connected for some time, even after it has completed its duplication. Meanwhile the sister cell, too, has become bispherical, and what a short while ago was a simple bispherical cell, has become a double bispherical body, resembling a small chain of four round joints. But the duplication does not stop; each of the four single cells, within a short time, doubles again; and soon quite a little rod or filament will be formed, which, on close inspection, presents a string or chain of bispherical cells, loosely connected endwise with each other. Under moderately high powers (say of 800 or 900 diameters) such a string represents a slender, rod-shaped moniliform *Bacterium*. While the single cells, or each half of each bispherical body, soon develop into double or spherical cells, the connexion between the latter gradually loosens, so that finally, if the temperature is not too low, and the development a rapid one (I have frequently observed that the number of bispherical cells in such a chain becomes doubled in less than five minutes), the chain breaks up into smaller ones (joints), each consisting of one or two bispherical Schizophytes, which, in separating from their neighbours, after some swinging to and fro, spin or draw out a very slender thread, a flagellum or cilium. But before all these changes (this rapid duplication) take place, the spherical *Micrococci*, when about to change to bispherical bodies, form those clusters (*Zoöglæa* or *Coccoglia* masses) which, being imbedded in, or kept together by, apparently viscous substance, obstruct the capillaries, and, according to my observations, constitute the principal and direct cause of the morbid process. In these *Zoöglæa*-masses the single *Micrococci*, it seems, undergo their first metamorphosis, or change to double bispherical cells; and this change continues till portions of the *Zoöglæa*-mass separate, or till finally the *Coccoglia* breaks and opens, when the bispherical bodies, and also some yet unchanged spherical *Micrococci*, become free. The former very soon commence their duplication; but as each new cell or globule soon produces another one and becomes bispherical, the same cannot be the source of the spherical bodies or *Micrococci*. The latter, it appears, have another origin, as will be presently explained.

In Swine-plague material, such as blood, blood-serum,

lung-exudation, &c., if a day or two old, and sometimes while yet fresh, *Bacteria* of a peculiar shape and form make their appearance. The same are rod-shaped, and a trifle longer than a bispherical Schizophyte, or two united spherical bodies, but are not moniliform, and have at one end, or, in comparatively rare cases, towards the middle, a bright and light-refracting globule of much more density than the rest of the *Bacterium*. This globule is surrounded by a substance or an envelope of considerably less density, and is therefore less light-refracting. If that globule is situated at one end of the *Bacterium*, as is usually the case, the whole *Bacterium* presents the shape of a club, because the globule and its envelope have much more diameter than the rod. Billroth calls this form a *Helobacterium*, and the globule a resting spore (Dauerspore). Such a resting spore, according to Billroth and Cohn, at any rate if developed by a *Bacillus*, is able to resist very high degrees of heat and cold, and is very prolific, as it disseminates a large number of germs, which probably constitute the source of the globular *Bacteria* or *Micrococci*. As such *Helobacteria* are often found in perfectly fresh blood and exudations &c. (in the exudations most frequently) of hogs which are affected with or have died of Swine-plague, and are nearly always seen if the blood and exudations &c. are a few days old, it appears probable that the same not only constitute the source of the spherical *Bacteria* or *Micrococci*, but also that their great tenacity of life, or resistibility against adverse external influences, explains the ability of the infectious principle of Swine-plague to remain effective for a whole year, if protected, by clinging to or being imbedded in a moist and porous substance, such as an old straw stack &c.

Whether or not Swine-plague Schizophytes are able to multiply in any other form and manner than stated, I have not been able to observe. One observation, made already at the beginning, has found new and repeated confirmation, viz.:—Wherever or as soon as *Bacterium termo* makes its appearance in large numbers, the Swine-plague Schizophytes begin to disappear, and disappear in about the same ratio in which the former are increasing in numbers. In blood kept in a vial Swine-plague Schizophytes cannot be found when the blood begins to exhibit a purplish colour, or when the blood-corpuscles begin to decay or become destroyed. Further, the Swine-plague Schizophytes, although presenting the same general characteristics when cultivated in fluids foreign to the animal organism of a hog, show differences in so far as they present less uniformity in size, and as this development and multiplication proceed slower and with much less regu-

larity. It seems the cultivated Schizophytes change and develop more slowly, and probably on that account are less vigorous in producing mischief; at any rate, an inoculation with cultivated Swine-plague Schizophytes, although effective in producing the disease, is always followed by a comparatively milder form of Swine-plague than an inoculation with material directly from the body of a diseased hog.† This, however, does not involve that every inoculation with cultivated Schizophytes produces under all circumstances a milder form of Swine-plague than any natural infection; for such is not the case. The difference may be stated thus:—A natural infection, or an inoculation with material directly from the body of a diseased hog, as a rule, produces a malignant and dangerous attack, and as an exception a mild form of the disease—the frequency of the exception depending, it seems, to a great extent, upon the prevailing character of the plague; while an inoculation with the cultivated Schizophyte is, as a rule, followed by a mild attack, and, as an exception, or in rare cases only, by Swine-plague in its severest form.

Wherever Swine-plague is prevailing in its most malignant or fatal form, or, what is essentially the same, wherever formation of ulcerous tumours in the cæcum and colon is a frequent occurrence, where consequently an abundance of Swine-plague Schizophytes is discharged with the excrements of the diseased animals, there the spreading from animal to animal, and from herd to herd, is a rapid one; and *vice versâ*, wherever the spreading is rapid, there ulcerous tumours in the intestines are a frequent occurrence. In 1878 the same (the ulcerous tumours) could be found in about 75 per cent. of all cases that had a fatal termination, while at present (in Illinois) their occurrence is probably limited to about 5 per cent. of all cases.

## PROCEEDINGS OF LEARNED SOCIETIES.

### GEOLOGICAL SOCIETY.

February 23, 1881.—Robert Etheridge, Esq., F.R.S.,  
President, in the Chair.

The following communication was read:—

“On *Astroconia Granti*, a new Lyssakine Hexactinellid from the Silurian Formation of Canada.” By Prof. W. J. Sollas, M.A., F.G.S.

This paper contained a description of a new fossil Hexactinellid sponge from the Niagara chert beds of Hamilton, Ontario. It is